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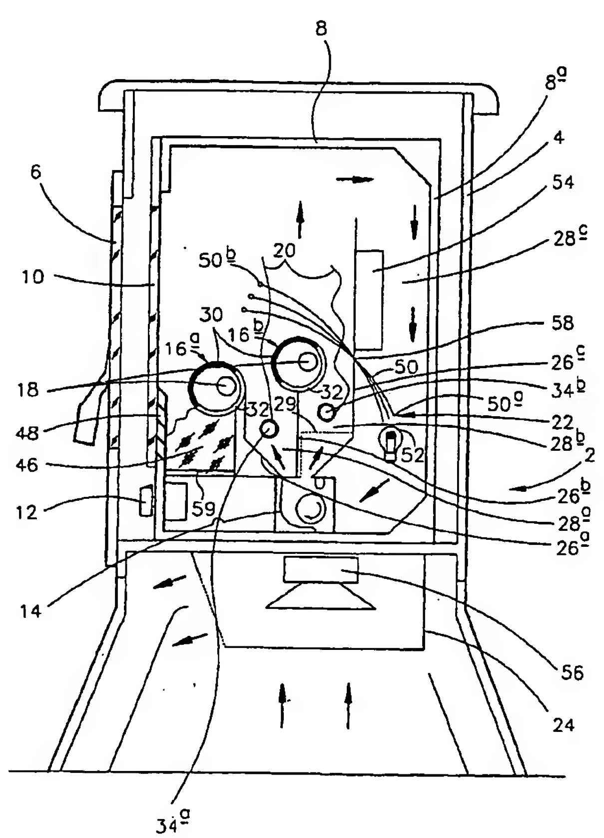

(57) Abstract: The present invention relates in a first aspect to a device for simulating combustion (2). The device (2) comprises at least one combustion-simulating element, preferably in the form of a flame-simulating element (20), having at least one fluorophoric region (20b) containing fluorophores which are capable of emitting visible light upon irradiation at a predetermined wavelength. The device (2) also comprises a radiation source (18) relatively positioned so as to irradiate said at least one fluorophoric region (20b) of the or each combustion-simulating element (20). In use, the or each fluorophoric region (20b) emits visible light by fluorescence due to irradiation by the radiation source (18), thereby simulating combustion. The device (2) is particularly suitable as a heating device, in which case a heat source (24) is provided. The present invention also relates to a spark simulating device (22) which comprises at least one optical fibre (50), and a light source (52), with the light source being operably coupled to the optical fibre(s) (50). The device (22) is arranged to transmit light from a first end of the fibre(s) (50a) to a second end (50b). There is also provided means for creating an observable pulse of light at the second end of the fibre(s) (50b) so as to simulate a spark.

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COMBUSTION SIMULATING DEVICE

The present invention relates, in a first aspect, to a device for simulating combustion and more particularly, but not exclusively, to a device for simulating combustion flames such as are produced, for example, in a solid fuel burning fire or stove.

Simulation of combustion has numerous advantages over real combustion:-

(i) very little heat is produced so the process is inherently safer (this is particularly significant for theatrical simulations where no heat is actually required),

(ii) there are no direct combustion products, so the process is environmentally clean,

(iii) chimneys or flues and gas, wood, peat, coal or oil supplies are not needed,

(iv) combustion-simulation systems are easy and quick to use and are virtually maintenance free, and

(v) in heating applications, the visual effect can be used independently of the heat supply.

Many attempts at simulating combustion (visually and/or aurally) have been made, but these generally suffer from one or more drawbacks.

In GB 2298073, simulated flames are generated by using a lamp to illuminate a rotating shaft fitted with reflective strips. Light reflected from

the strips is back-projected onto a diffusing screen. The simulated flames so produced appear flat and are less bright than real flames.

GB 1407926 discloses a simulated fireplace assembly in which flames are simulated by illumination (ambient light or by provision of light bulbs) of ornamental strips of thin and flexible material which flutter in an air stream. In GB 2323159, silk is caused to flutter in an air stream, the flame effect being generated by illumination of the silk by a directed beam of light from a spot light. Drawbacks of these systems are that (i) light is absorbed, reflected and scattered by the material giving a less realistic effect, and (ii) background structures are illuminated, reducing the contrast between the flame and the background.

US 3723046 and US 5594802 describe methods of producing the sound of a burning fire.

It is an object of first and second aspects of the present invention to provide an improved combustion-simulating device which preferably obviates or mitigates one or more of the aforementioned disadvantages.

It is an object of a third aspect of the present invention to provide a spark simulating device.

According to a first aspect of the present invention, there is provided a device for simulating combustion, said device comprising:-

(i) at least one combustion-simulating element having at least one fluorophoric region containing fluorophores capable of emitting visible light upon irradiation at a predetermined wavelength, and

(ii) a radiation source relatively positioned so as to irradiate said at least one fluorophoric region of the or each combustion-simulating element, wherein, in use, the or each fluorophoric region emits visible light by fluorescence due to irradiation by the radiation source, thereby simulating combustion.

Preferably, the radiation source emits UV light, preferably with a wavelength in the range of from 315 to 400nm, said range including said predetermined wavelength.

It will be understood that fluorophores may be selected which emit visible light at any wavelength required to give the desired combustion effect. Fluorophores emitting at different wavelengths may be combined, for example by selecting appropriate fluorophores, a simulated flame can be produced having any combination of violet, blue, light blue, yellow, orange and red components. Special flame effects, simulation of burning coals and special effects may include fluorophores emitting green light.

The combustion-simulating element may be a flame-simulating element or an ember simulating element.

It will be understood that real flames are dynamic. Thus, the device preferably includes means for effecting movement of said at least one

flame-simulating element when present. More preferably, said means comprise an air-flow generator.

In a preferred embodiment, the air-flow generator is arranged to generate a substantially vertically upwardly directed air flow, with the or each flame-simulating element being positioned above the air-flow generator, such that in use the flame-simulating element is supported in said air column. It will be understood that the weight and surface area of the or each flame-simulating element determines the speed of air required to support it.

The or each flame-simulating element when present is preferably a flexible material and more preferably a woven fabric, most preferably silk.

The or each fluorophoric region may be formed by providing said fluorophores on the surface of the flame-simulating element (eg. by painting, printing, spraying or dying) or by incorporating the fluorophores into the structure of the flame-simulating element, for example, in the case of a woven fabric, by introducing the fluorophore prior to or during the weaving process.

Preferably, the flame-simulating element, when present, is provided with at least one region containing non-fluorophoric pigments.

In a highly preferred embodiment, the flame-simulating element is formed from a white or light coloured material and is provided with fluorophoric regions, non-fluorophoric pigmented regions and unpigmented (i.e. substantially white, fluorophoric or non-fluorophoric) regions and the

radiation source is a UV lamp (315-400nm). In use, the fluorophoric regions glow, the non-fluorophoric-pigmented regions appear dark and the unpigmented regions may appear blue due to a visible light component emitted by the lamp, thereby simulating a real flame.

Preferably, the device includes real or simulated solid fuel elements such as log(s), coal, coke or candle wax. More preferably, the fuel elements are arranged in proximity to the flame-simulating elements so that, in use, the latter appear to emanate from the former.

Preferably, the device includes an ember-simulating element. Said element may comprise fluorophores which simulate embers when illuminated by UV light. Alternatively, or in addition, the ember-simulating element may comprise translucent material which simulates embers when illuminated by visible light. The same UV source may be used to illuminate the flame-simulating element and the ember-simulating element. Visible light and/or UV light may be provided by reflection from the or each flame-simulating element. Alternatively, separate UV or visible light sources may be provided. A fluorescent, non-fluorescent, or reflective light director may be provided and arranged to direct light (UV and/or visible) onto the ember-simulating element.

The ember-simulating element may be in the form of a multi-faceted light emitter (eg. crumpled fluorescent paper or fabric) or a multi-faceted reflector (eg. crumpled aluminium foil).

The device may be a heating appliance in which case it also comprises a heat source. Suitable heat sources include convector heaters, fan assisted electric fires and electric radiators.

According to a second aspect of the present invention, there is provided a device for simulating combustion, said device comprising:-

(i) a flame-simulating element comprising flexible material,

(ii) flame-simulating-element height-adjustment means attached to said flame-simulating element, wherein the height adjustment means is arranged to effect movement of the flame-simulating element between a first position in which a relatively large portion of the flame-simulating element is visible from a predetermined position external to the device and a second position in which a relatively small portion of the flame-simulating element is visible from said predetermined position.

Preferably, the second position corresponds to a position in which none of the flame-simulating element is visible from said predetermined position.

Preferably, the height adjustment means comprises a rotatable member (eg. a roller or spindle) to which the flame-simulating element is secured, such that, in use, movement between the first and second positions is effected by winding the flame-simulating element onto or off the rotatable member.

Automatic means may be provided to control the height adjustment means (eg. an electric motor operably connected to the height adjustment means).

The device may be a heating appliance in which case it includes a heat source. The height adjustment means may be operably coupled to the heat source, such that the position of the flame-simulating element is dependent upon the heat setting of the heating appliance (i.e. towards the first position at higher heat settings and towards the second position at lower heat settings). Conversely, the height adjustment means and the heat source may be operably coupled such that the heat setting of the heating appliance is dependent upon the position of the flame-simulating element.

The flame-simulating element is preferably removably attached to at least part of the height adjustment means, for example by the use of double sided adhesive tape. Alternatively hook and eye type fastenings may be used. This facilitates replacement of the flame-simulating element should it become necessary for replacement or repair. More preferably, the flame-simulating element and said at least part of the height adjustment means are separable as a single unit from the rest of the device.

More than one flame-simulating element may be provided, in which case more than one height adjustment means may also be provided.

The device of the second aspect of the invention is preferably also in accordance with the first aspect of the invention.

According to a third aspect of the present invention, there is provided a spark simulating device comprising:-

(i) at least one optical fibre,

(ii) a light source operably coupled to said at least one optical fibre and arranged to transmit light from a first end of said fibre to a second end, and
(iii) means for creating an observable pulse of light at the second end of the fibre so as to simulate a spark.

In a first series of embodiments, the pulse-creation means comprises means for successively switching the light source on and off. The switching means may be actuated manually. Alternatively, an automated actuator may be provided which is capable of causing periodic, preferably random, switching of the switching means.

Preferably, means are provided for varying the wavelength (colour) and brightness of the light source during each pulse and/or from one pulse relative to another. This can be effected by the provision of a variable voltage supply to the light source during pulses (eg. by providing a capacitor) or from one pulse to the next (eg. by providing a variable resistor).

In a preferred embodiment, the light source is a filament lamp and the pulse creation means comprises a capacitor which is arranged to discharge through the filament lamp under control of the switching means. It will be understood that the use of a capacitor generates a high initial voltage through the filament lamp which rapidly diminishes. The effect observed at the second end of the optical fibre(s) is an initial bright pulse which gradually fades and simultaneously changes colour from white/yellow to red.

Preferably, agitating means are provided to cause the second end of the fibre optic to move randomly.

In a second series of embodiments, the pulse creation means comprises a visualisation member, and agitating means are provided to cause the second end of the optical fibre(s) to periodically strike the visualisation member, the simulated spark being created upon striking of the illuminated second end of the optical fibre(s) on the visualisation member.

In said second series of embodiments, the light source may be a UV light source, in which case the visualisation member is provided with a fluorophoric region which emits light when struck by the illuminated second end of the optical fibre(s). The visualisation member may be a simulated fuel element a screen or other object having a fluorophoric coating. It will be understood that by using UV light, the optical fibre(s) can be continuously illuminated without being seen by an observer between strikes on the visualisation member.

Alternatively, a translucent screen may be provided between the optical fibre(s) and an observer which when struck by the illuminated optical fibre(s) on one side, causes a simulated spark to be observable on its opposite side. Since the optical fibres are hidden behind the screen continuous illumination is possible with the light seen by an observer between strikes being minimised.

The agitating means may be electromechanical (eg. an electromechanical plunger), a current of air, or a flame-simulating element of a combustion-simulating device.

Preferably, sound generation means are provided to simulate the noise of a spark. In the cases where the simulated spark is generated by switching the light source on and off, the sound generation means is preferably synchronised with the switching of the light source. In the cases where the simulated spark is generated by impact on a visualisation member, the sound generation means is preferably synchronised with the agitating means.

The device may be a simulated firework, or may form part of a simulated combustion device (eg. a device in accordance with the first and/or second aspects of the present invention).

Embodiments of the present invention will now be described by way of example only, with reference to the accompanying drawings in which:-

Fig 1 is a schematic perspective view of part of a combustion simulating device in accordance with the first and second aspects of the invention in the form of a stove, incorporating a spark simulating device in accordance with the third aspect of the present invention,
Fig 2 is a cross-sectional view of the stove of Fig 1,
Fig 3 is a perspective detail of the stove shown in Fig 1,
Figs 4 and 5a show alternative means of attachment of a flame-simulating element to a spindle,

Fig. 5b shows a modified spindle arrangement,

Fig 6 shows an enlarged end of an optical fibre,

Fig 7 is a schematic circuit diagram of the spark simulating device shown in Fig 1

Figs 8 and 9 are schematic representations of spark simulating devices in accordance with the third aspect of the present invention,

Fig 10 is a spark simulating device in the form of a firework,

Fig 11 is a circuit diagram for Fig 10,

Figs. 12a and 12b are front and side views respectively of an alternative rear log incorporating an air-flow deflector, and

Figs. 13a and 13b show typical flame simulating elements.

Referring to Figures 1 and 2, a combustion-simulating device in the form of a stove 2 comprises an outer housing 4 having a glass-fronted door 6 and an inner housing 8 having a removable transparent panel 10 aligned with the door 6 of the outer housing 4. The outer housing 4 is made from cast iron but other materials such as wood, MDF, fibre glass, aluminium or plastic can be used. Stove controls 12 are provided on the front of the inner housing 8. In an alternative arrangement (not shown), the control relating to the "intensity" of the combustion simulation (see below) and/or the actual heat output is located on the door 6 disguised as the air control knob of a real fuel burning stove. Preferably, inner surfaces of the inner housing 8 are painted matt black. Provided in the inner housing 8 are a DC crossflow fan 14 (Type Q2G030-GCO1-01, Ziel-EBM (UK) Ltd, Chemsford, UK), front and rear spaced apart hollow simulated logs 16a,16b, an ultraviolet light tube 18 (Type TL 8W/08F8T5/BLB, Philips, Holland) contained in each log 16a,16b so as to be hidden from view,

front and rear flame-simulating elements 20, and a spark simulating device 22. A fan assisted fire 24 is located on the underside of the outer housing.

The inner housing 8 is also provided with first, second and third spaced apart baffle plates 26a,26b,26c which define first, second and third air flow channels 28a,28b,28c between the front and rear logs 16a,16b, between the rear log 16b and the third baffle plate 26c, and between the third baffle plate 26c and a rear wall 8a of the inner housing 8 respectively. Open spaced wire mesh 29 extends across the second air flow channel 28b from the third baffle plate 26c towards the second baffle plate 26b and then downwardly below the second baffle plate 26b across the first air flow channel 28a to the first baffle plate 26a. The wire mesh 29 serves as a finger guard, preventing fingers and flame elements 20 from touching the blades of the fan 14. In addition, the wire mesh 29 allows the flame elements 20 to rise more readily when the fan 14 is switched on.

The logs 16a,16b have an opaque region 30 towards the front of the stove 2 and a UV transparent region 32 towards the rear of the stove 2. In the present embodiment, the logs 16a and 16b are made from cardboard tubing and a UV-transparent window, made from plastics film, is provided at the rear of each log 16a,16b. The windows follow the contour of the logs 16a,16b to allow smoother air flow around the logs 16a,16b and better flame movement but these are not essential. As an alternative to the cardboard tubing, pigmented fibre glass, plastic mouldings or papia mache may be used, again, fitted with UV-transparent windows. To avoid having separate windows, the logs 16a,16b may be made from UV-transparent plastics material and opaque pigment, or separate textured forms applied

to selected areas at the front of the logs 16a,16b. In the case where plastics or fibre glass logs are used, their inside surface is advantageously coated with a static dissipative (preferably transparent) coating such as Staticide Gold (OK International, Eastleigh, UK) in order to prevent the build up of static electricity. This coating ensures that, in use, the flame simulating elements 20 do not become attached to the logs 16a,16b, so preventing them from fluttering in the airflow. Additionally, selected front-facing areas, particularly the upper and lower parts of the logs 16a,16b may be transparent or translucent and may have red pigmentation (not shown) to simulate partial burning in use. In the present embodiment this is achieved by drilling small holes into the logs 16a,16b.

In a slight modification (Figs. 12a and 12b), a front underside region 33 of the rear log 16b is wedge shaped with a substantially planar surface 33a which is substantially tangential to the part-circular main region 35 of the log 16b and a substantially planar undersurface 33b extending horizontally rearwardly of the log 16b from the end of the planar surface 33a remote from the main region 35 of the log 16b. Mounting flanges 37 extend downwardly from the underside region 33 at either end of the log 16b. In use, the planar surface 33a and horizontal undersurface serve as an air-flow deflector which improves the air flow characteristics over the front flame-simulating element 20.

Each flame-simulating element 20 is a shaped piece of silk fabric (other light flexible materials or fabrics could be used) cut into a "flame-shaped" pattern. Although the shape of the flame-simulating elements 20 is not

critical, a more realistic effect is obtained if the silk flame-simulating elements 20 are asymmetrical.

Referring to Fig. 13a, a typical flame simulating element 20 is shown. The element comprises a rectangular base region 20a from which first 21a, second 21b and third 21c flame shapes extend. The second (middle) flame shape 21b tapers asymmetrically outwardly from its intersection with the base region 20a and then asymmetrically inwardly to a point at its end remote from the base region 20a. The combination of asymmetry and the fact that the flame shape 21b is widest intermediate its ends causes increased instability (and therefore greater realism) in the airflow. The third flame shape 21c is provided with a cut 23 extending from its outer edge, approximately across half its width.

Referring to Fig. 13b another flame-simulating element is shown. In this example, the second (middle) flame shape 21b is a compound flame shape formed with a number of asymmetrical tapering regions 25.

It should be noted that the inventors have found that the most realistic flame simulating elements do not have the expected geometry of natural flames. The realism arises from the movement of the flame simulating elements 20 in the airflow.

In the present embodiment, the edges of the silk material are treated to minimise fraying. Some regions are coloured with a non-fluorescent black silk paint (20a, see Fig 3) (Philip & Tracey, Andover, UK). Depending upon the desired effect, other colours of paint or dye can be used. Other

regions are coloured with transparent fluorescent orange fabric paint (20b, see Fig 3) (Setacolor, Pebeo, Gemenos Cedex, France) and some edge regions (20c, see Fig 3) are not painted or dyed. Any suitable method of painting, dying, and printing may be used to apply the pigments to the silk. The pigments are fixed by heating in an oven at 150°C for 5 minutes. During the pigmentation process, the silk may lose some of its flexibility, in which case it can be restored by crumbling the silk and opening it out. The effect obtained will vary according to the colours of paint (fluorescent and non-fluorescent) used, the shape and distribution of the painted and non-painted regions (20a,20b,20c), the density and distribution of pigment within each region and the degree to which the interfaces between the various regions are merged.

The front and rear flame-simulating elements 20 are secured by double sided adhesive tape to front and rear spindles 34a,34b respectively (front spindle 34a shown part cut-away in Fig 1). The front spindle 34a is rotatably mounted in the first air flow channel 28a below the logs 16a,16b. The rear spindle 34b is rotatably mounted in the second air flow channel 28b also below the logs 16a,16b. Each spindle 34a,34b extends through the inner and outer housings 8,4 on one side of the stove 2 and is provided with a turning knob 36 which is manually operable from externally of outer housing 4.

Referring specifically to Fig 3, the front spindle 34a is mounted to the inner housing 8 by means of adjustable brackets 38. The brackets 38 allow adjustment of the positioning of the spindle 34a vertically and longitudinally of the stove 2 (indicated by arrows A and B respectively).

The spindle 34a is also adjustable laterally (indicated by arrow C) of the stove 2 so that the optimum flame effect is obtained. The rear spindle 34b is similarly mounted. The provision of mounting brackets 38 also facilitates removal of the spindle-flame assembly for repair or replacement.

In a slight modification of the above embodiment, shown in Figs 4 and 5a, alternative flame-spindle assemblies are provided. In Fig 4, the silk flame 20 is hemmed to form a sleeve into which the spindle 34 is inserted. The spindle 34 and attached silk flame 20 are slotted into a tube 40 having a longitudinal slit 40a through which the silk flame 20 projects. This arrangement reduces the possibility of puckering the silk flame 20 during assembly. In Fig 5a, the spindle 34 has a recessed flat surface 42 intermediate its ends. Secured to the flat surface 42 is one element of a hook and eye-type fastening 44. The other element of the hook and eye type fastening 44 being secured to an edge of the silk flame 20. It will be understood that this arrangement allows easy replacement of the silk flame without any substantial dismantling of the device.

In another modification, shown in Fig. 5b, the inner housing 8 is provided with keyhole apertures 45. The spindle 34 has a pointed conical end 47 remote from the turning knob 36, and a region of reduced diameter 49 adjacent the turning knob 36. The pointed conical end 47 facilitates fitting of the spindle 34 through the keyhole apertures 45. The reduced diameter region 49 of the spindle 34 permits limited lateral adjustment of the spindle 34 (arrow A).

Referring again to Figs 1 and 2, the fan 14 is located at the base of the inner housing 8 below the logs 16a,16b and is arranged to blow air upwardly into the first and second channels 28a,28b and over the silk flame-simulating elements 20. It will be understood that in other embodiments (not shown) the fan 14 may be located elsewhere, the only requirement being that the fan 14 is arranged to blow air substantially upwardly over the flame-simulating elements 20. The fan 14 is provided with a speed control (not shown) to adjust the flow of air into the first and second channels 28a,28b. A bypass switch (not shown) is also provided to bypass the fan speed control in order to apply full voltage to the fan motor. This can be used to temporarily increase the air flow to ensure that the flame-simulating elements 20 unfold and rise effectively.

Located on top of the fan 14 between the front of the inner housing 8 and the first baffle plate 26a is an ember simulator 46 in the form of orange fluorescent paper which has been crumpled and partially opened out and covered with orange cellophane. When illuminated by UV light, a random ember effect is observable through slots 48 in the front of the inner housing 8. In an alternative embodiment (not shown), the ember simulator 46 is made from a reflective material such as aluminium foil which has been crumpled up and partially opened out to make a multifaceted random reflector. In said alternative embodiment, lower parts of the first and second baffle plates 26a,26b are transparent (eg. by the provision of acrylic windows) thereby allowing undulating (orange) visible light reflected from lower ends of the simulated flames 20 to reach the reflective material. The effect is seen as shimmering glowing embers.

In a modification of said alternative embodiment, the baffle plates 26a,26b are entirely transparent (eg. made entirely from acrylic).

In another alternative embodiment, the ember simulator 46 is a hollow vacuum formed, glass fibre, or injection moulded component painted at least in part with fluorescent paint. In order to improve illumination, a reflector/diffuser 59 may be provided, made from fluorescent, non-fluorescent or reflective material. The use of such an ember simulator allows the desired effect to be consistent from one stove to another.

The spark simulating device 22 comprises optical fibres 50, a filament lamp 52, a housing for control electronics 54 and a loudspeaker 56. The optical fibres 50 are 0.25mm diameter polymeric fibre optic light guides (Universal Fibre Optics, Colstream, Scotland). At one of their ends 50a, the optical fibres 50 are brought together and potted into a ferrule using glue, with subsequent polishing of the potted ends 50a. The potted ends 50a are secured in close proximity to the filament lamp 52 (5V, 90mA lamp, VCH International W440649601, Farnell 328-467 Leeds, UK). The lamp 52 and potted ends 50a of the optical fibres 50 are held in a light-tight housing (not shown) located behind the third baffle plate 26c to prevent reflected light from the lamp 52 being observed in use. The optical fibres 50 pass through a hole 58 provided in the third baffle plate 26c so that their free ends 50b are above the logs 16a,16b. A clamping and adjustment mechanism (not shown) is provided to allow positioning of the free ends 50b with respect to the logs 16a,16b and to an observer. Since the free ends 50b are not held together the fibres 50 splay apart in a random manner. The free end 50b of each fibre 50 is enlarged to about

0.5 mm diameter (figure 6) and optically polished by positioning that end 50b near to the side of a real flame. The enlarged 'optically' polished free end 50b provides a brighter and larger simulated spark for a given diameter of fibre 50. Small diameter fibres 50 are advantageous since they are less visible, lighter, more flexible and move more readily in an air flow (see below). An alternative method of polishing and enlarging the free ends 50b is to dip the end 50b in a clear polymeric solution such as Tensol 70 (Evode Speciality Adhesives, Leicester).

When the stove 2 is switched on, the fan 14, ultraviolet light tubes 18 and spark-simulating device 22 are energised. The fan 14 draws air down the third channel 28c and up into the first and second channels (28a,28b) over the silk flame elements 20. The air is then recirculated back down the third channel 28c (air flow indicated by arrows in Fig 2). Since the inner housing 8 is totally enclosed by the outer housing 4, fan noise is reduced and build-up of dust within the stove 2 is prevented. Since the silk fabric is very light, the silk flame elements 20 flutter in the upwardly directed air flow, when unwound from their respective spindles 34a,34b. Adjustment of the air flow velocity alters the perception of the "intensity" of the flame. For any given device, there will be an air flow velocity below which and above which the flame effect is unacceptably unrealistic. Thus, the fan 14 may be fitted with a mechanism which, in normal use, only permits air flow velocities within a predetermined range. If a fan bypass switch is fitted, this can be used when commissioning the stove or when fitting new flame-simulating elements. The height of each observable flame element 20 is adjusted by rotating the appropriate spindle turning knob 36 in one direction to wind the silk flame element 20 off its spindle 34a,34b, or in

the other direction to wind the silk flame element 20 onto its spindle 34a,34b. The winding and unwinding is facilitated by the air flow from the fan 14. When the stove is not in use, each silk flame element 20 can be completely wound onto its spindle 34a,34b and so be hidden from view. It will be appreciated that the realism of the effect is determined by the geometry of the logs 34, the shape of the flow channels 28a,28b,28c and the shape and pigmentation of the flame-simulating elements 20.

The free ends 50b of the optical fibres 50 move randomly in the air flow and may also be moved by interaction with the silk flame elements 20. When the spark simulating device 22 is activated (see below), sparks appear to emanate from in front of, behind and above the silk flame elements 20 and the loudspeaker 56 emanates a crackle. The orientation and small diameter of the fibres 50 are such that the enlarged ends 50b of the fibres 50 are prominently visible during sparking, and the fibres 50 are minimally visible. Since the fibres 50 are in constant random motion, the sparks appear at random locations.

The UV lamps 18 generate a diffuse non-focused light having a small visible component at the blue end of the spectrum. Substantially the whole of each silk flame element 20 is illuminated by the diffuse light. Not only do the UV lamps 18 provide an elongated source of UV light, they are considerably cheaper to run and generate much less heat than a filament lamp. The fluorophoric regions 20b fluoresce red/orange. Since light is actually being emitted from the silk flame elements 20 and there is virtually no visible light observable from the lamps 18 within the housing 8, the flames appear bright and there is a high contrast with the

background. The regions 20a of the flame elements 20 coated with non-fluorescing pigments appear dark and provide the illusion of smoke within the flames or the absence of flame. The uncoated edges 20c of the silk flame elements 20 appear blue-tinged due to reflection of the small component of visible blue light. The overall effect of the fluorescence, non-fluorescence and reflection, in conjunction with the random motion of the silk flame elements 20 is a convincing "living" flame effect. The effect can be further enhanced by varying the voltage, and hence light output, of the tubes 18 either manually or automatically.

The front UV lamp 18 also illuminates the fluorescent paper and cellophane (ember simulator 46) below the front log 16a, generating an orange glow which gives the illusion of glowing embers.

The fan assisted fire 24 draws cold air upwardly and blows warmed air out of the front of the stove 2. In this embodiment the fire 24 operates independently of the simulated flame device. In an alternative embodiment, the spindles 34a,34b securing the silk flame elements 20 are motorised, with the motor being coupled to the fire 24, such that the height of the flame elements 20 is adjusted according to the heat setting of the fire 24 . It is of course possible to couple the fire 24 with the spindles 34a,34b (either manual or motorised) in such a manner that the heat setting of the fire 24 is adjusted according to the position of the spindles 34a,34b (i.e. simulated flame height). Indeed, various elements of the stove 2 such as brightness of logs 34, speed of fan 14, height of flame-simulating elements 20, sparks, thermostatic control and on/off times may

all be controlled automatically by a microcomputer. Additionally the stove 2 may be controlled remotely via infrared or other wireless means.

Referring to Fig 7, the lamp 52 and loudspeaker 56 of the spark simulating device 22 are connected to an electrical circuit comprising a power supply 60 (5-12V), a 47,000μF electrolytic capacitor 62 (16V working), a relay operated switch 64, a multivibrator 66 (of conventional design utilising a flashing LED kit (VX76, Maplin Electronics, Rayleigh, Essex), a random event generator 68 ('Electronic Digidice' kit VT03D, Maplin), a variable resistor 69 and a relay coil 70.

The components are arranged in the circuit so that the multivibrator 66 triggers the random event generator 68 which energises the relay coil 70, which in turn operates the relay switch 64, thereby discharging the capacitor 62 through the lamp 52 and loudspeaker 56 simultaneously. Although the multivibrator 66 is a cyclic device its cycling rate is relatively inconsistent compared with the cycling of the binary counter of the random event generator 68, thereby assuring randomness in the activation of the relay coil 70. The frequency of the multivibrator 66 (and hence the average interval between relay activations) is controlled by the variable resistor 69.

The initial charging voltage determines the initial brightness of the pulse of light. At 12 volts the light, seen from the free ends 50b of the optical fibres 50 is firstly white, going yellow to red and then extinguishing in less than a second. The observed brightness and size of each fibre 50 differs during

and between pulses because the angle which the fibre 50 presents to an observer is random.

The above spark simulating device 22 may be modified to include electronic means of varying the lamp brightness between light pulses (eg. an additional random event generator). Alternatively, a moving filter disc with varying densities or colours may be interposed between the lamp and optical fibres. Alternatively, or in addition to either of the above modifications, more than one lamp may be used, each lamp being located in proximity to a different set of fibres.

Referring to Figure 8, an alternative embodiment of a spark simulating device 22 involves back projection to produce the spark effect. A bundle of optical fibres 50 is continuously illuminated by a lamp 52. A diffusing screen 71 (for example of the type described in GB 2298073) is interposed between an intended observation point 72 and the optical fibres 50. A spring return, push type solenoid 74 is pulsed electrically (means not shown) and this causes the ends 50b of the optical fibres 50 to momentarily strike the diffusing screen 71 in a random manner. This is seen as burst of sparks at the observation point 72. Current to the solenoid 74 is simultaneously applied to a loudspeaker (not shown) to provide the sound of sparks. A light shield 76 between the lamp 52 and the diffusing screen 71 prevents direct viewing of he lamp 52 at the observation point 72. It will be understood that this spark simulating device can be used in place of the spark simulating device in the combustion-simulating device described with reference to Fig 1, in which case the diffusing screen 71 could also serve as the third baffle plate.

Referring to Fig 9, a device is shown similar to that of Fig 8. In this embodiment, the lamp 80 is a UV lamp, and a bundle of fibres 50 which transmit UV light is interposed between a transparent screen 82 and the intended observation point 72. The screen 82 is provided on one side with a substantially transparent fluorophoric coating 82a which produces visible light on being struck by the fibre ends 50b (in this embodiment under the action of a push type solenoid 74) creating an illusion of a shower of sparks.

It will be understood that in other embodiments, the optical fibres can be arranged to strike any object (eg. a simulated log) having a fluorophoric coating.

Referring to Figs and 10 and 11, a hand-held device for safely simulating firework-like sparks comprises a bundle of optical fibres 50 fixed at one end 50a in a housing 90 and a lamp 52 within the housing in close proximity to the fixed ends 50a of the fibres. The optical fibres 50 extend out of the housing 90 and splay towards their free ends 50b. The housing 90 additionally contains an on/off switch 92, an electrolytic capacitor 94, a battery 96, a loudspeaker 56 and a microswitch 98. The activating lever of the microswitch 98 is provided with a mass 98a.

In use, an operator rocks the device (indicated by arrow A). The inertia and weight of the mass 98a cause the microswitch 98 to operate and the lamp 52 to pulse. Simultaneously, the free ends 50b of the optical fibres 50 move randomly and a display of simulated sparks is visible. The

advantage of this device over a real firework is that is safe to use indoors and outside and can be used repeatedly. Similar devices could be scaled-up to provide displays in public places.

CLAIMS

1. A device for simulating combustion, said device comprising:-
(i) at least one combustion-simulating element having at least one fluorophoric region containing fluorophores capable of emitting visible light upon irradiation at a predetermined wavelength, and
(ii) a radiation source relatively positioned so as to irradiate said at least one fluorophoric region of the or each combustion-simulating element, wherein, in use, the or each fluorophoric region emits visible light by fluorescence due to irradiation by the radiation source, thereby simulating combustion.

2. A device according to claim 1, wherein the radiation source emits UV light with a wavelength in the range of from 315 to 400nm, said range including said predetermined wavelength.

3. A device according to claim 1 or 2, wherein said at least one combustion-simulating element is a flame-simulating element.

4. A device according to claim 3, additionally comprising means for effecting movement of said at least one flame-simulating element.

5. A device according to claim 4, wherein said movement effecting means comprises an air-flow generator.

6. A device according to claim 5, wherein the air-flow generator is arranged to generate a substantially vertically upwardly directed air flow,

with the or each flame-simulating element being positioned above the air-flow generator, such that in use the or each flame-simulating element is supported in said air column.

7. A device according to any one of claims 3 to 6, wherein the or each flame-simulating element is formed of a flexible material.

8. A device according to any one of claims 3 to 7, wherein said at least one flame-simulating element is provided with at least one region containing non-fluorophoric pigments.

9. A device according to any one of claims 3 to 8, wherein the or each fluorophoric region is formed by painting, printing, spraying or dying said at least one flame-simulating element.

10. A device according to any one of claims 3 to 9, wherein said at least one flame-simulating element is provided with fluorophoric regions, non-fluorophoric pigmented regions and unpigmented regions, and the radiation source is a UV lamp having a wavelength range of 315 to 400nm.

11. A device according to any preceding claim additionally comprising real or simulated solid fuel elements such as at least one log, coal, coke or candle wax.

12. A device according to claim 11, wherein said fuel elements are arranged in proximity to the flame-simulating elements so that, in use, the latter appear to emanate from the former.

13. A device according any preceding claim additionally comprising an ember-simulating element.

14. A device according to claim 13, wherein said ember simulating element comprises fluorophores which simulate embers when illuminated by UV light.

15. A device according to claim 14, wherein the same UV source is used to illuminate the flame-simulating element and the ember-simulating element.

16. A device according to any one of claims 13 to 15, wherein the ember-simulating element is in the form of a multi-faceted light emitter or a multi-faceted reflector.

17. A device according to any one of claims 13 to 16, wherein the ember-simulating element comprises translucent material.

18. A device in accordance with any one of claims 13 to 17, wherein a fluorescent, non-fluorescent or reflective light director is provided, said light director arranged to reflect UV and/or visible light onto the ember-simulating element in use.

19. A device according to any preceding claim which additionally comprises a heat source.

20. A device for simulating combustion, said device comprising:-

(i) a flame-simulating element comprising flexible material,

(ii) flame-simulating element height-adjustment means, at least a part of which is attached to said flame-simulating element, wherein the height adjustment means is arranged to effect movement of the flame-simulating element between a first position in which a relatively large portion of the flame-simulating element is visible from a predetermined position external to the device and a second position in which a relatively small portion of the flame-simulating element is visible from said predetermined position.

21. A device according to claim 20, wherein said second position corresponds to a position in which none of the flame-simulating element is visible from said predetermined position.

22. A device according to claim 20 or 21, wherein the height adjustment means comprises a rotatable member to which the flame-simulating element is secured.

23. A device according to any one of claims 20 to 22, additionally comprising automatic means to control the height adjustment means.

24. A device according to any one of claims 20 to 23, additionally comprising a heat source.

25. A device according to claim 24, wherein the height adjustment means is operably coupled to the heat source, such that the position of the flame-simulating element is dependent upon the heat control setting of the heat source.

26. A device according to any one of claims 20 to 25, wherein the flame-simulating element and said at least part of the height adjustment means are separable as a unit from the rest of the device.

27. A device according to any one of claims 20 to 26, wherein the flame-simulating element is removably attached to said at least part of the height adjustment means.

28. A device according to any one of claims 20 to 27, wherein more than one flame-simulating element is provided.

29. A device according to any one of claims 20 to 28 which is also in accordance with any one of claims 1 to 19.

30. A spark simulating device, said device comprising:-
(i) at least one optical fibre,
(ii) a light source operably coupled to said at least one optical fibre and arranged to transmit light from a first end of said fibre to a second end, and
(iii) means for creating an observable pulse of light at the second end of the fibre so as to simulate a spark.

31. A device according to claim 30, wherein the pulse-creation means comprises switching means for successively switching the light source on and off.

32. A device according to claim 30 or 31, wherein an automated actuator is provided to cause periodic switching of the switching means.

33. A device according to any one of claims 30 to 32, wherein means are provided for varying the wavelength and brightness of the light source during each pulse and/or from one pulse relative to another.

34. A device according to any one of claims 30 to 33, wherein the light source is a filament lamp and the pulse creation means comprises a capacitor which is arranged to discharge through the filament lamp under control of the switching means.

35. A device according to claim 30, wherein the pulse creation means comprises a visualisation member, and agitating means are provided to cause the second end of the at least one optical fibre to strike the visualisation member, the simulated spark being created upon striking of the illuminated second end of the at least one optical fibre on the visualisation member.

36. A device according to claim 35, in which the light source is a UV light source, and the visualisation member is provided with a fluorophoric region which emits light when struck by the illuminated second end of the at least one optical fibre.

37. A device according to claim 35, wherein the visualisation member is a translucent screen provided between the at least one optical fibre and an observer which when struck by the at least one illuminated optical fibre on one side, causes a simulated spark to be observable on its opposite side.

38 A device according to any one of claims 35 to 37, in which the agitating means is electromechanical, a current of air, or a flame-simulating element of a combustion-simulating device.

39. A device according to any one of claims 30 to 38, wherein sound generation means are provided to simulate the noise of a spark.

40. A device according to claim 39 when appended to any one of claims 31 to 34, wherein the sound generation means is synchronised with the switching means.

41. A device according to claim 39 when appended to any one of claims 35 to 38, wherein the sound generation means is synchronised with the agitating means.

42. A device according to any one of claims 30 to 41, wherein said device forms part of a simulated combustion device in accordance with any one of claims 1 to 29.

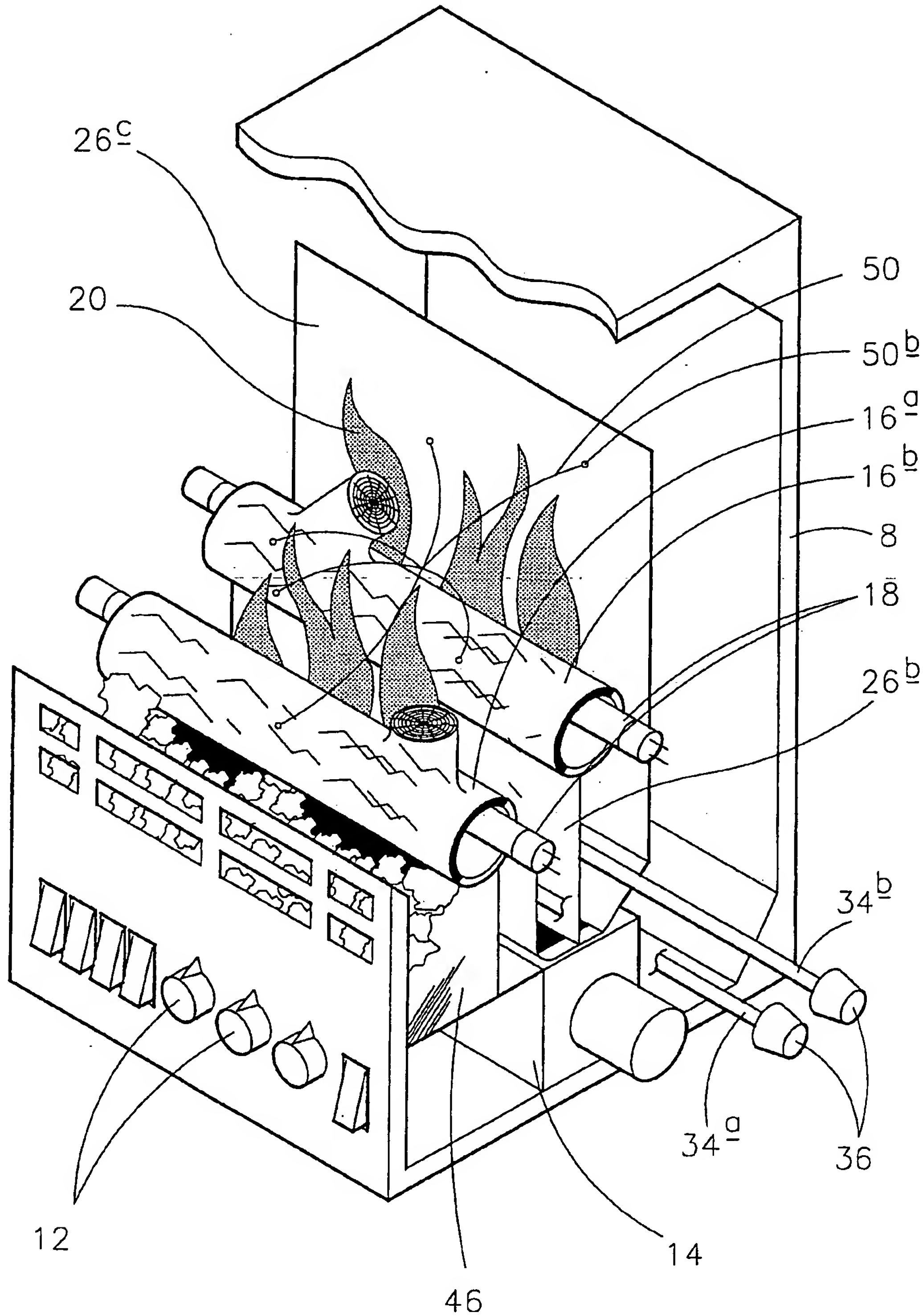

FIG.1

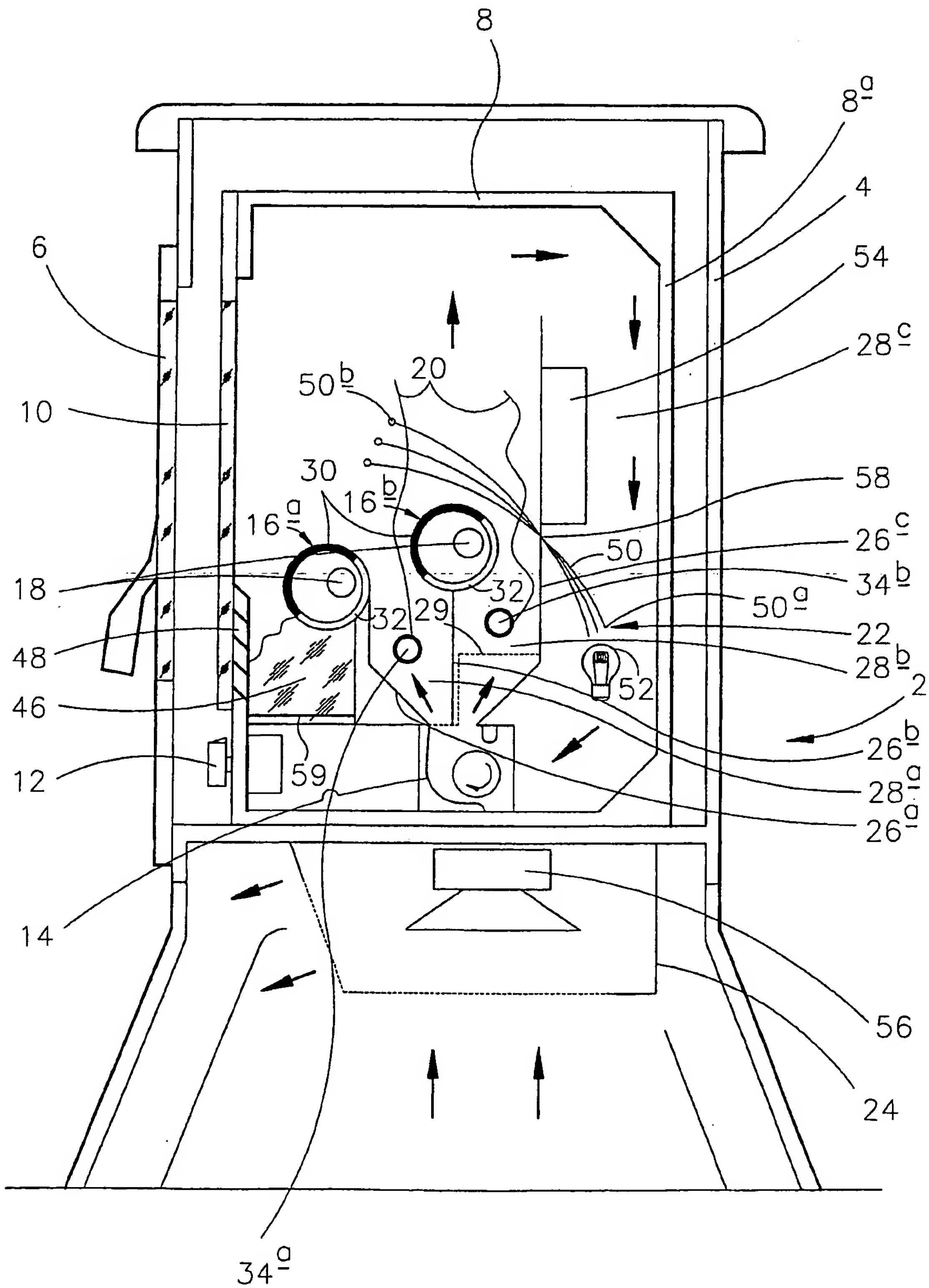
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FIG.2

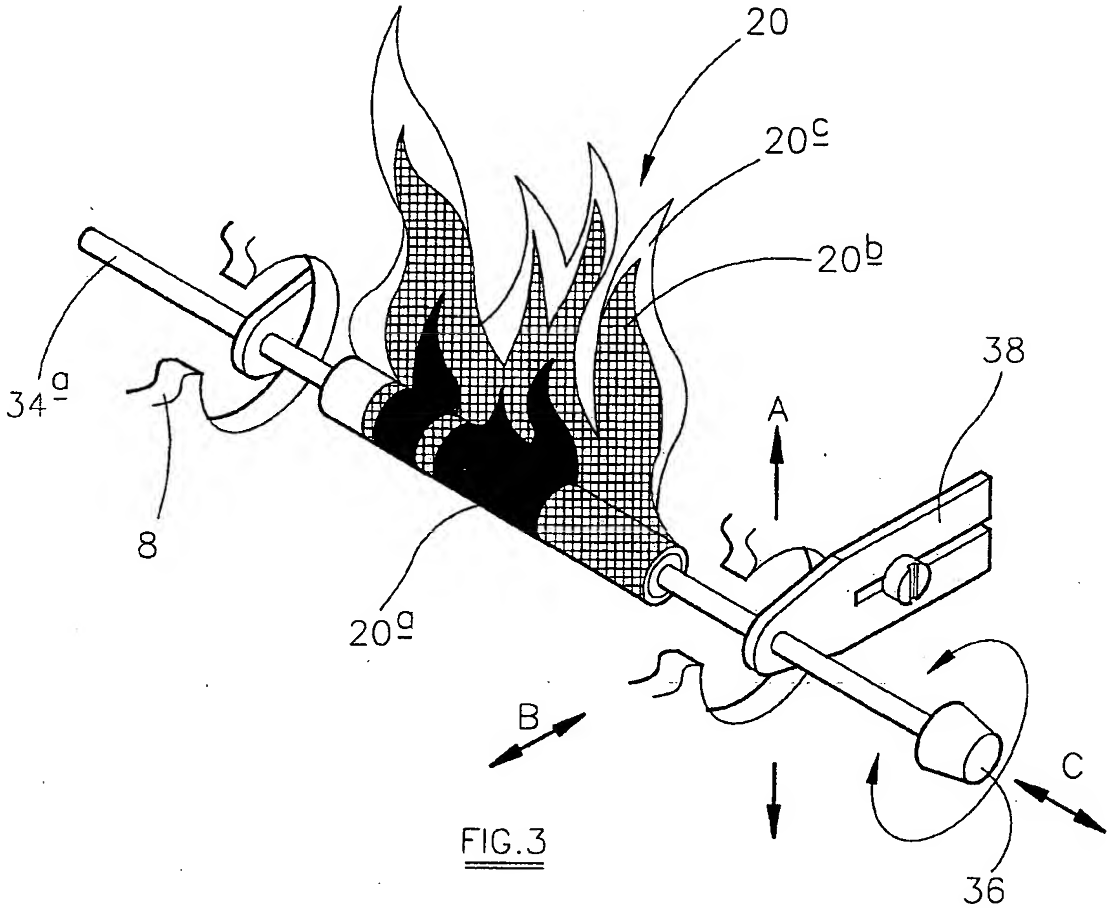

FIG.3

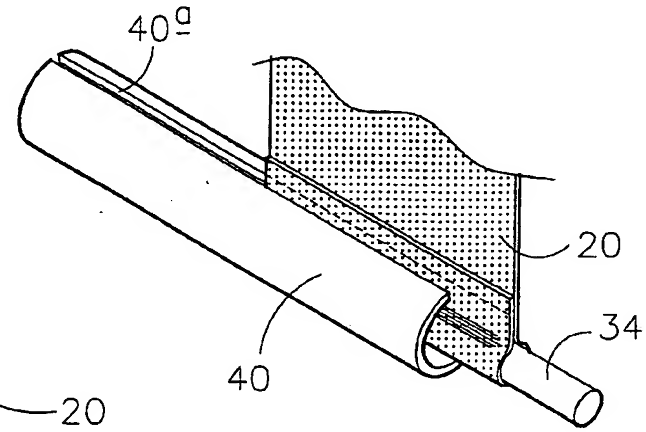

FIG.4

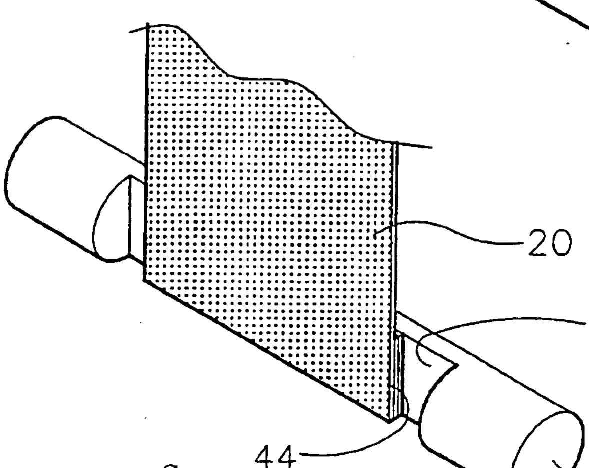

FIG.5a

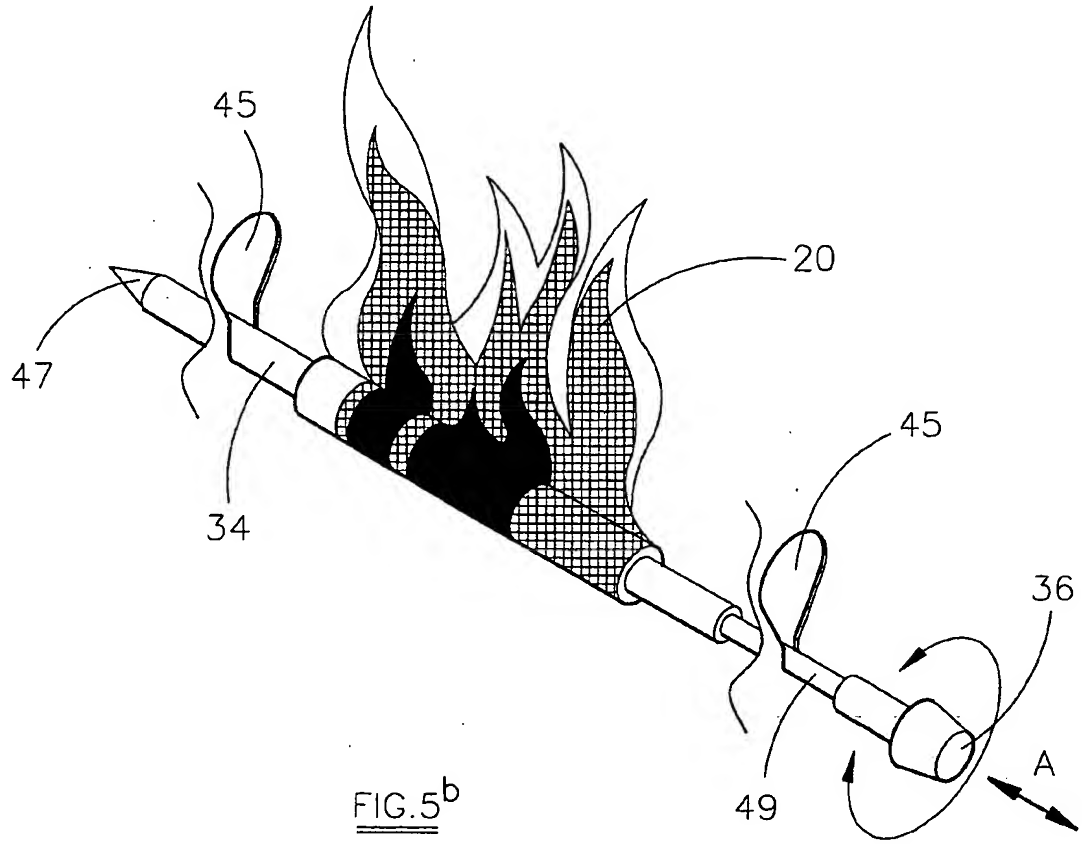

FIG.5b

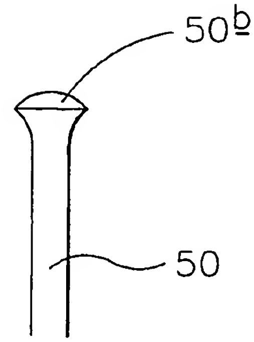

FIG.6

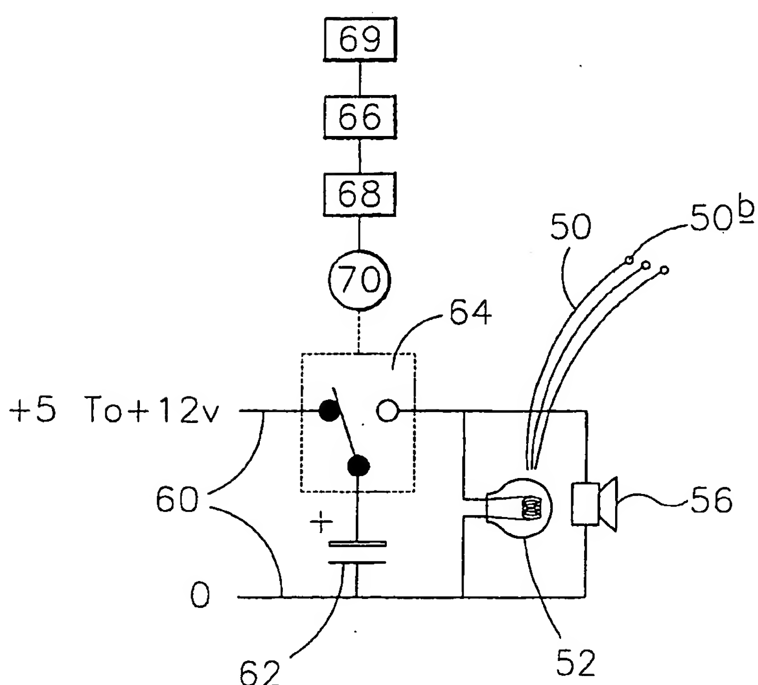

FIG.7

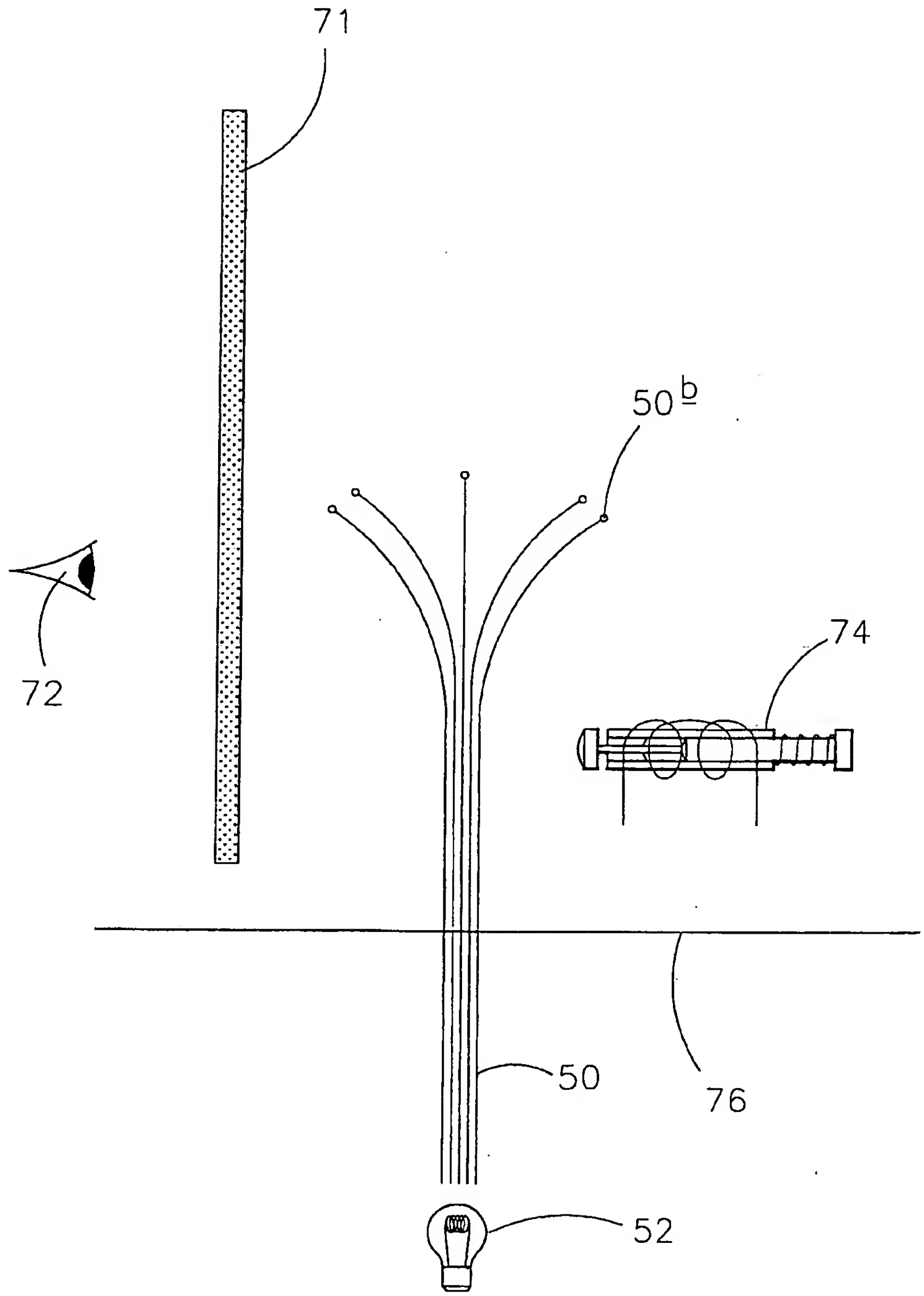

FIG.8

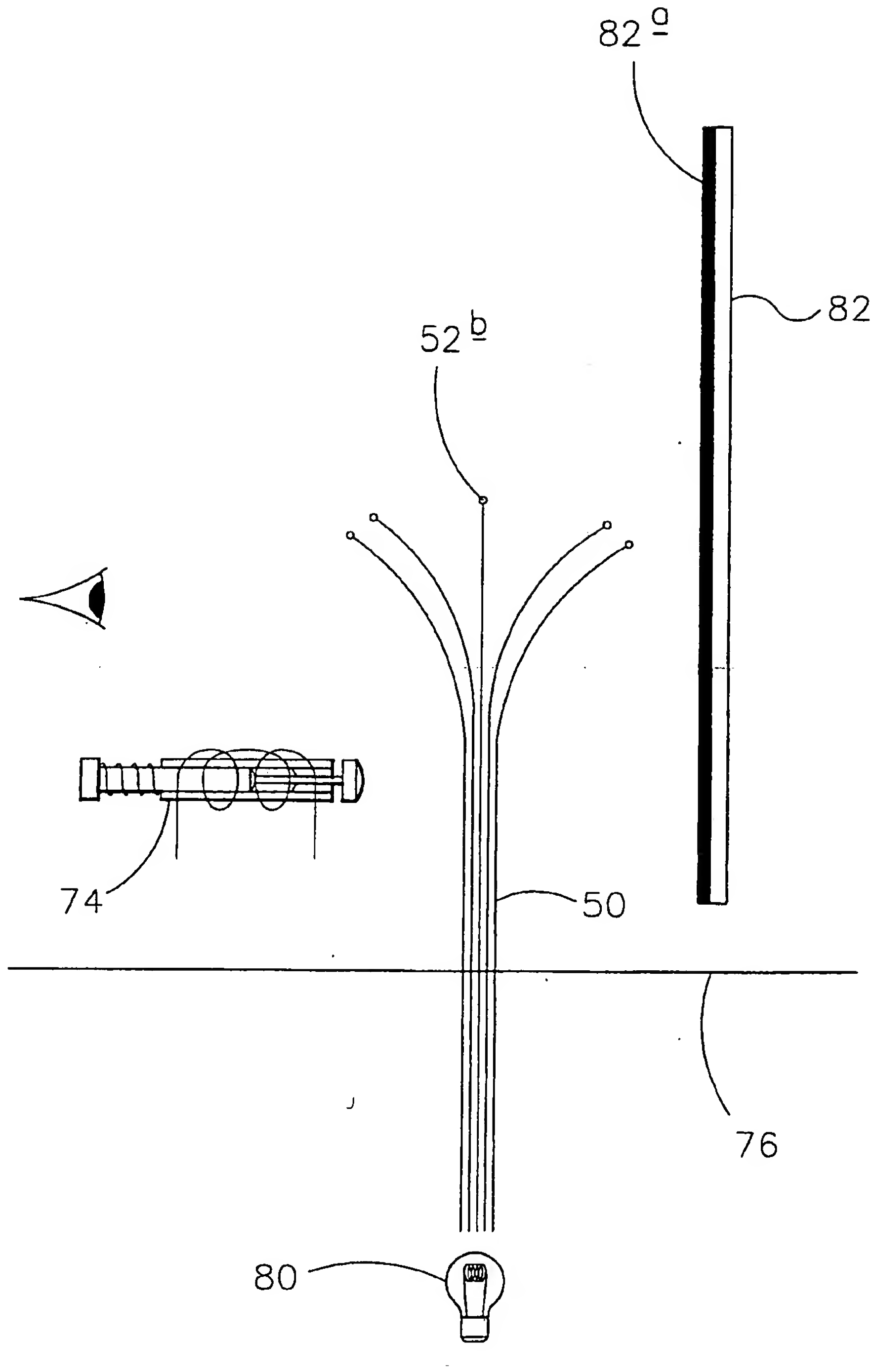

FIG.9

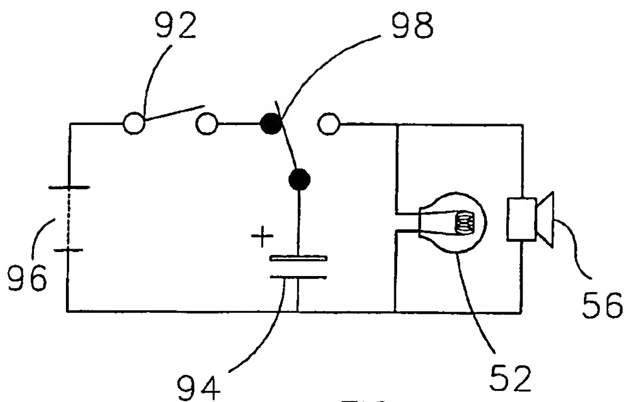

FIG.11

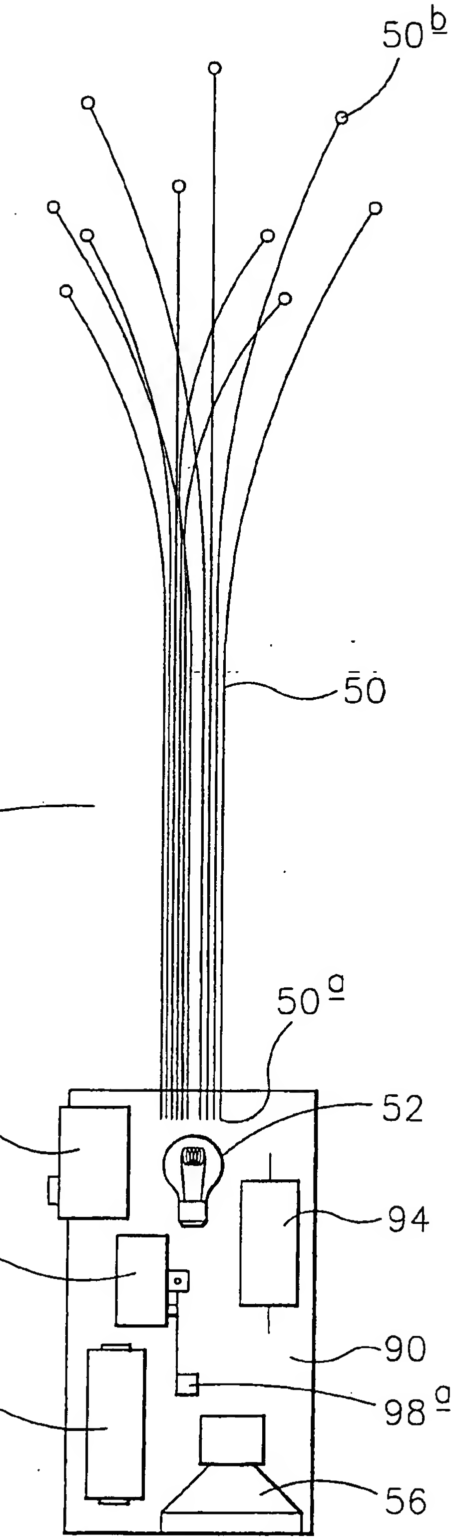

FIG.10

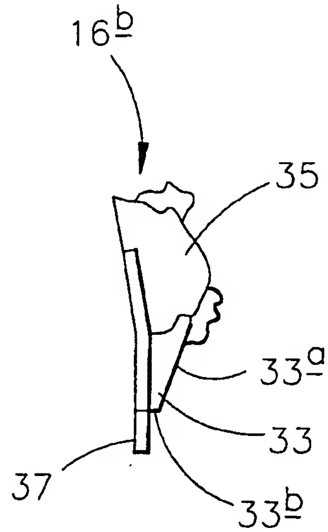

FIG.12b

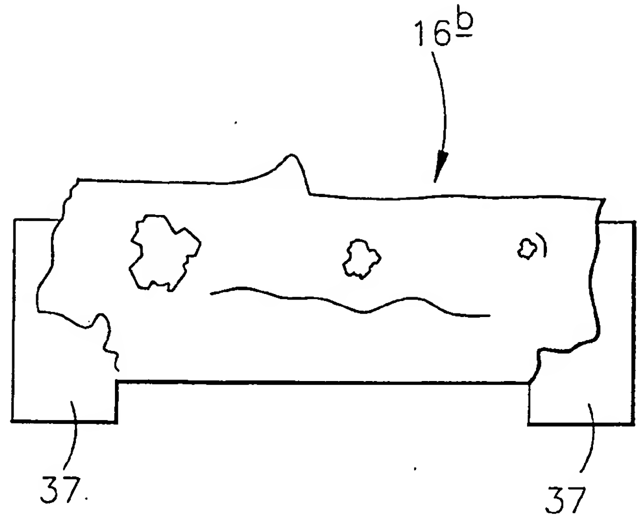

FIG.12a

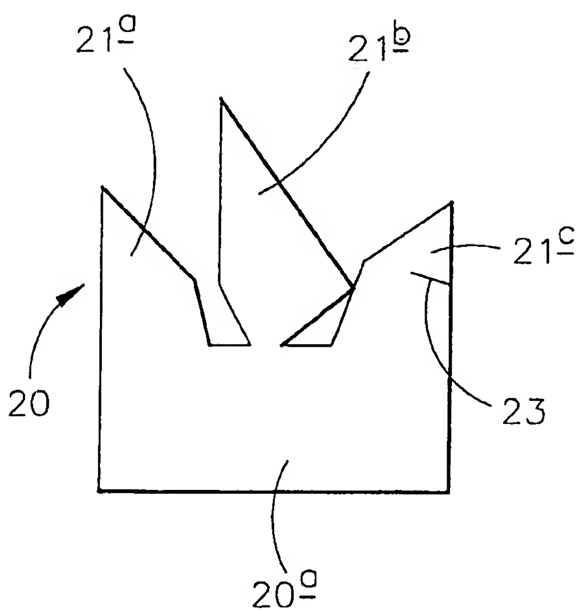

FIG.13a

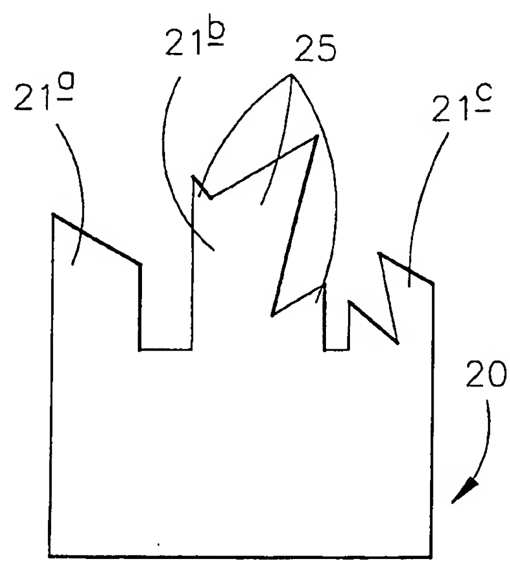

FIG.13b

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 01/00243

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F24C7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F24C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 241 575 A (CREDA LTD) 4 September 1991 (1991-09-04) the whole document	1-7,9,11

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 June 2001	12/06/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Vanheusden, J

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 01/00243

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2241575 A	04-09-1991	NONE	